USAFA-TR-97-11

Bombs, Babies and Ball Games: Fostering Intellectual Curiosity in Basic Statistics

Marie A. Revak
Bradley A. Warner

Department of Mathematical Sciences

United States Air Force Academy
Colorado Springs, Colorado 80840

DECEMBER 1997

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DEAN OF THE FACULTY
UNITED STATES AIR FORCE ACADEMY
COLORADO 80840

USAFA TR 97-11

This research report, entitled "Bombs, Babies and Ball games: Fostering Intellectual curiosity in basic statistics" is presented as a competent treatment of the subject, worthy of publication. The United States Air Force Academy vouches for the quality of the research, without necessarily endorsing the opinions and conclusions of the author. Therefore, the views expressed in this article are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the US Government.

This report has been cleared for open publication and public release by the appropriate Office of Information in accordance with AFM 190-1, AFR 12-30, and AFR 80-3. This report may have unlimited distribution.

Donald R. Erbschloe

DONALD R. ERBSCHLOE, Lt Col, USAF
Director of Research

31 Dec 97
Date

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1997	Final Report Sep 1996-May 1997

4. TITLE AND SUBTITLE
Bombs, Babies, and Ball Games: Fostering Intellectual Curiosity in Basic Statistics

5. FUNDING NUMBERS

6. AUTHOR((S)
Marie A. Revak and Bradley A. Warner

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Department of Mathematical Sciences. USAF Academy. CO 80840

8. PERFORMING ORGANIZATION REPORT NUMBER
USAFA-TR-97-1.1

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

"Fostering intellectual curiosity" is an important educational goal at most colleges and universities and has been highlighted as a key educational outcome at the United States Air Force Academy. In this study, we analyze the effect of choice of projects on the intellectual curiosity of Air Force Academy cadets enrolled in a basic statistics course. Cadets chose from three alternative projects which applied the same probability and statistical concepts, but set these concepts in different topical contexts. Our results indicate that when students were given a choice of project, they both enjoyed the project more and were more interested in the topic of the project, but this enjoyment did not translate into improved scores.

14. SUBJECT TERMS
intellectual curiosity

15. NUMBER OF PAGES
17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

Bombs, Babies, and Ball Games:

Fostering Intellectual Curiosity in Basic Statistics

Marie A. Revak

Bradley A. Warner

This study investigated the effect of student choice of projects on the intellectual curiosity of students enrolled in a core (required) basic statistics course. The sample consisted of 267 United States Air Force Academy cadets all in their Sophomore or Junior year. Achievement and survey data were collected. The outcomes measured include scores on the projects and responses to survey questions intended to measure intellectual curiosity. The cadets enjoyed the projects more and proclaimed a deeper interest in the topic when they were allowed to select the topic. One group indicated that they would like to learn more about their project topic. However, students with a choice of projects did not achieve higher project scores.

Bombs, Babies, and Ball Games:

Fostering Intellectual Curiosity in Basic Statistics

Abstract

"Fostering intellectual curiosity" is an important educational goal at most colleges and universities and has been highlighted as a key educational outcome at the United States Air Force Academy. In this study, we analyze the effect of choice of projects on the intellectual curiosity of Air Force Academy cadets enrolled in a basic statistics course. Cadets chose from three alternative projects which applied the same probability and statistical concepts, but set these concepts in different topical contexts. Our results indicate that when students were given a choice of project, they both enjoyed the project more and were more interested in the topic of the project, but this enjoyment did not translate into improved scores.

Bombs, Babies, and Ball Games:

Fostering Intellectual Curiosity in Basic Statistics

One of the goals of the United States Air Force Academy (USAFA) is to produce Air Force Officers who are intellectually curious; officers that are driven to learn more about a subject than what is merely required by the assigned task. During the Fall 1996 semester, faculty convocations were held in each department to discuss helps and hindrances to academic curiosity. A recurring theme in these discussions was that student choice is essential to the development of intellectual curiosity.

Our goal in this research was to determine whether we could increase the intellectual curiosity of cadets by allowing them to choose a project topic from three alternatives. The three alternative topics applied the same probability and/or statistical concepts but set these concepts in different contexts, therefore appealing to the different interests of the cadets.

The following research questions were established:

(1) Will students with a choice of projects achieve better scores?

(2) Will students with a choice of projects spend more time on their projects?

(3) Will students with a choice of projects enjoy the project more?

(4) Will students with a choice of project show more interest in the mathematics of the project?

(5) Will students with a choice of project show more interest in the topic of the project?

(6) Will students with a choice of project show a greater appreciation for probability and statistics?

(7) Will students with a choice of project gain more knowledge of probability and statistics?

(8) Will students with a choice of project want to learn more about probability and statistics?

(9) Will students with a choice of project want to learn more about the project topic?

We also established research questions to improve the quality of our projects in future semesters:

(10) Will certain project topics appeal more to female students?

(11) Will certain project topics appeal more to students with specific academic majors?

(12) Will students prefer choosing a project to choosing a partner?

(13) Will students prefer to work alone or work as part of a team?

(14) Will students prefer to do a project designed by instructors or design their own projects?

Method

Participants

Math 300 (Probability and Statistics) is a core course required for graduation from the USAFA (Mathematics and Operations Research majors are required to take a more challenging statistics course). Enrollment in this course was 409 at the beginning of the Spring 1997 semester and 402 at the end of the semester. The sample for this study consisted of the 267 cadets for which a full data set (achievement and survey data) was available. All students were sophomores or juniors.

For reference, the mean Scholastic Achievement Test (SAT) mathematics score for USAFA cadets entering the Air Force Academy ranges from 610 to 710. American College Testing (ACT) mathematics scores range from 26 to 31. About 69 percent of cadets who enter the Air Force Academy are in the top tenth of their high school graduating class. About 16 percent of cadets are women. Eighteen percent have minority ethnic backgrounds (Office of Institutional Research, US Air Force Academy, 1996).

Math 300 was chosen for this study because cadets enrolled in Math 300 have traditionally exhibited a low level of motivation and intellectual curiosity. All students in the Fall 1996 offering of this course responded "definitely false" to the statement "I had a strong desire to take this course" on the Instructional Development and Effectiveness Assessment (iDEA) student critique (Center for Faculty Evaluation and Development, Kansas State University, 1988).

Procedures

The syllabus for Math 300 includes four projects, one near the end of each block of instruction. Only the Block II and Block III projects were included in this study. The 22 sections (classes with about 20 students per class) of the course were divided into two groups with 11 sections in each group. Nine instructors were assigned to teach the course and all nine participated in the

experiment. To minimize instructor workload, all of an instructor's sections were randomly assigned to one of the two groups. The study employed a design in which group I had a choice of three alternatives for the Block II Project and group II had a choice of three alternatives for the Block III Project. The group that did not have choice of project had instead a choice of partners. This design allowed all students the opportunity for choice of project and not partner for one project and then choice of partner and not project for the other project. This was done to give the cadets a sense of fair treatment. In addition, it provided the opportunity to determine which is more desirable; choice of project or choice of partner.

The focus of the Block II project was probability. Three parallel projects were designed (see Appendix 1). Students in the sections with a choice of Block II project (group I, treatment group) were provided with a one paragraph description of each of the three projects and instructed to choose the project that appealed to them most (see Appendix 1). Instructors then assigned students to two and three person teams according to the project chosen (two-person teams were the standard). The teams were formed within sections.

Students in the remaining sections (group II, comparison group) were instructed to select a partner to work on the assigned project as a team (sections with an odd number of students had one three-person team). Students were not pre-briefed on the study, but were told that some sections had a choice of projects and other sections had a choice of partners.

The treatment and comparison groups were switched for the Block III project. Group II became the treatment group and group I became the comparison group. The focus of the Block III project was hypothesis testing. Again, three parallel projects were designed (see Appendix 2) and students in the sections with a choice of project were asked to choose a project based on a one-paragraph description.

The course topics, textbook, handouts, reading assignments, and homework assignments were identical for the two groups. To control for grading variations, each instructor was assigned to grade only one of the three projects using a standardized scoring rubric.

Results

Group Parity

Before comparing project scores for the two groups, we compared hourly exam scores to ensure that the groups were approximately equal in mathematics aptitude. Analysis of scores for the three hourly exams revealed that the two groups had comparable probability and statistics ability (using a multivariate analysis of variance to account for the correlation between hourly exams while simultaneously testing for equality of hourly exam mean scores resulted in a p-value of 0.6139). Figure 1 plots the distribution of exam scores for the two groups. It is also apparent from this graph that the mean scores for each exam were not statistically different. See Table 1 for descriptive data on the exam scores.

Project Scores

Figure 2 is a plot of the distribution of scores for the Block II project. These two distributions were compared using a two-sample Kolmogorov-Smirnov test. The results indicate that the two groups have the same distribution of scores ($p = .45$). The Kolmogorov-Smirnov test was used because it not only compares the means of the two distributions, but also all the higher order moments such as variance and skewness.

Figure 3 is a plot of the distribution of scores for the Block III project. Again, these two distributions were compared using a two-sample Kolmogorov-Smirnov test. The results indicate that the two groups have the same distribution of scores ($p = .49$).

See Table 2 for descriptive data on project scores.

Surveys

Students responded to surveys about the projects after the projects were turned in but before they were scored. The first survey referenced the Block II project. The survey revealed that, when contrasted with students in group II, students in group I (the treatment group): (1) enjoyed working on the project more ($t = 3.0$, $df = 253$, $p = 0.003$); (2) were more interested in the project topic ($t = 4.48$, $df = 253$, $p \approx 0$); (3) improved their knowledge of probability and statistics more ($t = 2.68$, $df = 264$, $p = 0.008$); and (4) wanted to learn more about the project topic ($t = 3.37$, $df = 246$,

$p = 0.001$).

Treatment and comparison groups were switched for the Block III project. After the Block III project was collected by the instructors, the students responded to a second survey. The survey revealed that, when contrasted with students in group I (the comparison group), students in group II (the treatment group): (1) spent more time working on the project ($t = 2.28$, $df = 241$, $p = 0.023$); and (2) were more interested in the project topic ($t = 2.05$, $df = 228$, $p = 0.041$).

The results of the two student surveys are reported in Table 3.

Additional survey items were analyzed to determine which projects were preferred by students and whether project choices correlated with gender or academic major.

Analysis of the first survey revealed that over 55 percent of students chose the "Bombs" project, 31.3 percent chose the "Ball Games" project, and 13.4 percent chose the "Babies" project (see Appendix I for project descriptions). Percentages for female students were 38.1, 33.3, and 25.6 respectively. Percentages for male students were 59.3, 30.8, and 1.0 respectively (see Table 4). Three categories for academic majors were created. The 54 students majoring in basic sciences, biology, chemistry, computer science, math, operations research, physics, and space operations were classified "Major A;" the 49 students enrolled in engineering majors were classified "Major B;" and the 164 remaining students majoring in humanities, social sciences, English, economics, geography, history, legal studies, management, and political science were classified "Major C." The "Bombs" project was the top choice by students in all categories of major (see Table 4).

Similar analyses were performed using items on the second survey. Of those students given a choice, 44.5 percent of the students selected the "Food for Thought" project, 41.9 percent selected the "College Life" project, and 13.5 percent selected the "Military Life" project (see Appendix 2 for project descriptions). Over 65 percent of the female students chose the "Food for Thought" project, with the remainder of the female students split evenly between the "Military Life" and "Collegiate Life" projects. The most preferred project for male students was "Collegiate Life" (47.6 percent), with 39.7 percent choosing "Food for Thought" and 12.7 percent choosing "Military Life" (see Table 4). "Food

for Thought" was the top choice for students in Major A, "Collegiate Life" was the top choice for Major B, and the top choice for Major C was evenly split between the two (see Table 4).

Additional questions on the second survey asked students to define their preferences. Fifty-six percent of the students preferred a choice of partner over a choice of project. Only 20 percent preferred to choose their project; 24 percent had no preference. Most students (72 percent) preferred to work with a team. Only 12 percent preferred to work alone while 17 percent had no preference. A majority of students (58 percent) responded that they preferred a project designed by the course instructors over a project they designed themselves (14 percent), with 28 percent having no preference (see Table 5).

Discussion and Conclusions

When students were given a choice of three projects they both enjoyed the project more and were more interested in the topic of the project. This seems self-evident; we expected students to choose topics they were interested in. For Project II, this also translated into a student sense of improved knowledge of probability and statistics and a desire to study the topic more. These same results were not reflected in the Project III survey even though the treatment group here indicated that they studied more. The best summary for this analysis is that students enjoyed the topic and project more if they were given a choice of topic, but this enjoyment did not translate into improved scores.

Another interesting finding was that even though students enjoyed the project more if they selected the topic, they stated that they preferred to select their partner to selecting the topic. This finding may be partially explained by the course being a required course outside of students' area of interest. Because mathematics is potentially a difficult subject, students may be more comfortable working with someone they know. Students may also prefer to choose a partner to lower their risk of being assigned a "dud" for a partner. We recommend replicating the experiment in a course with math majors and compare choice of project with choice of partner. In this study, "choice" is defined as a student selecting one of three projects designed by instructors, thus, a weak manipulation of student choice. We recommend a stronger manipulation of student choice; a study in which students choose from among a larger array or projects or design their own projects.

We did find that gender and major impacted the choice of topic. This again seems like a forgone conclusion, but it is often overlooked in a class where only one project topic is offered. An area of further research would be to compare these survey results with the results from a course in which students develop their own project topics. In our study only a small number of students indicated they would prefer to develop their own project.

In our core course, students appeared to be in a survival mode. They were interested in doing what was necessary to complete the class. Although our results indicate that the students in the study preferred to work in teams of their own choosing with a project developed by the instructor, students with a choice of project exhibited better attitudes toward the project. We recommend that student choice be more fully incorporated into required college courses and that a more robust application of student choice be investigated.

Figure 1. Distribution of the hourly exam scores for the two groups.

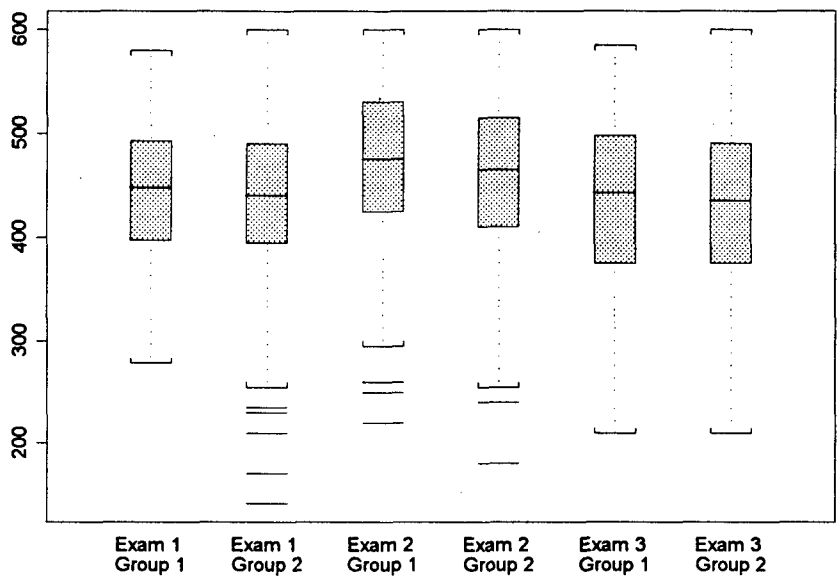

Figure 2. Distribution of scores for Block II project.

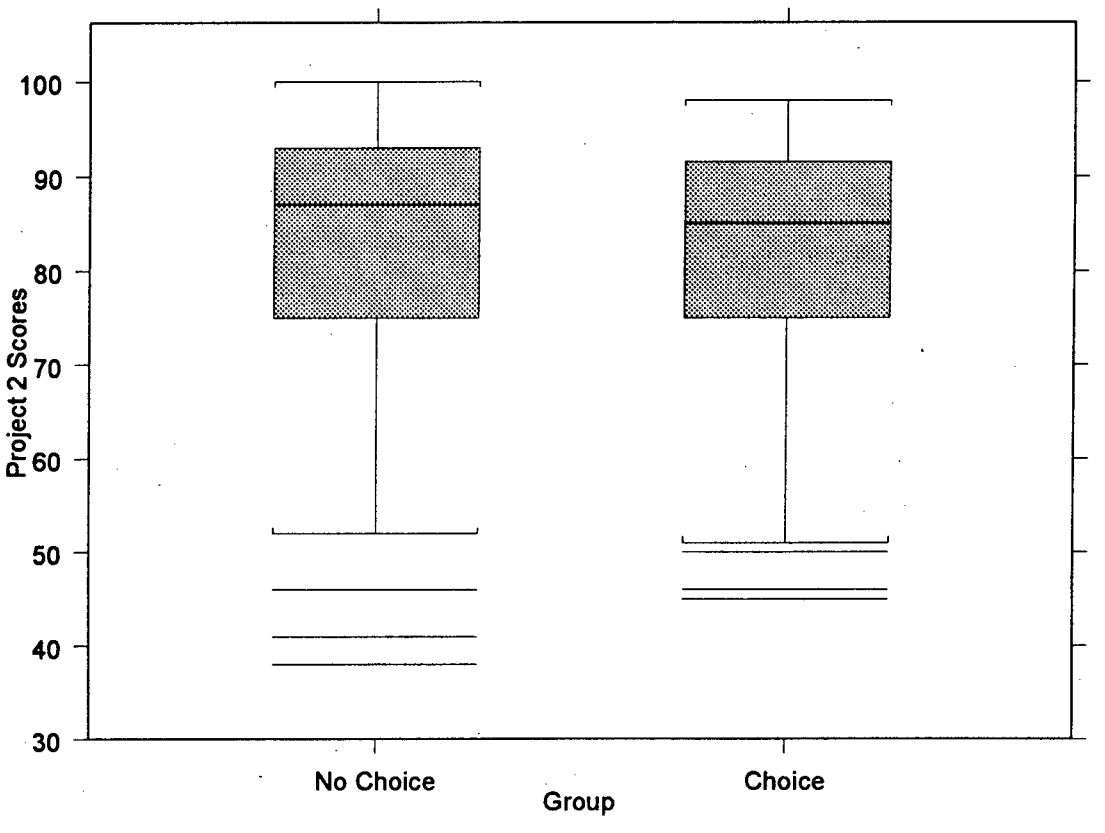

Figure 3. Distribution of scores for Block III project.

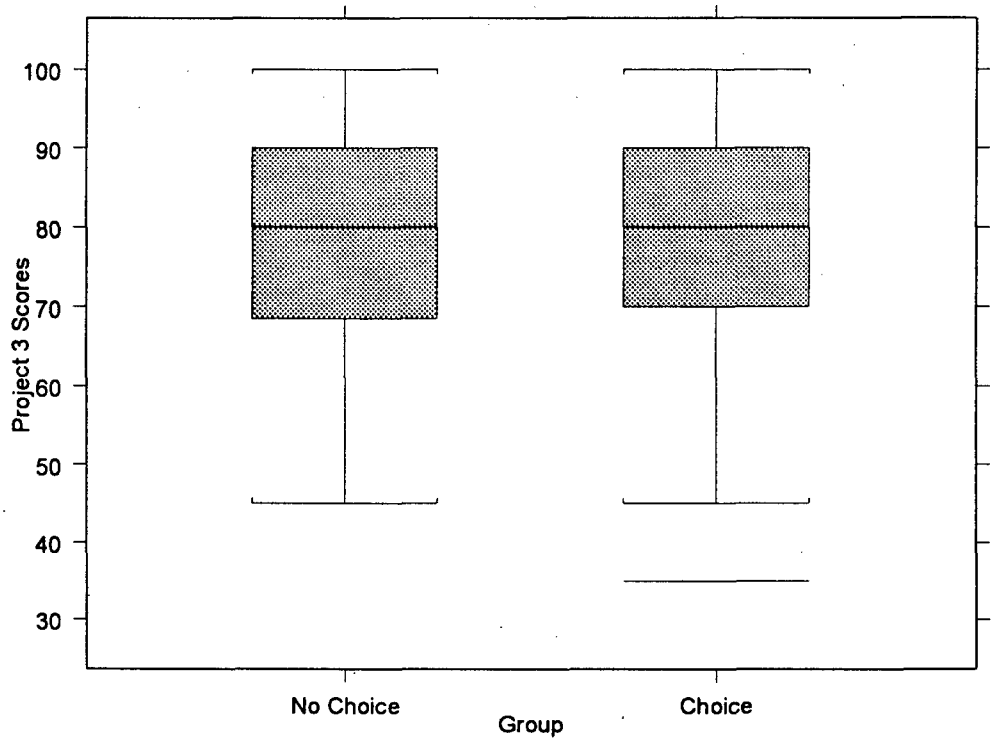

Table 1

Exam Scores

	Exam 1		Exam 2		Exam 3	
	Group I	Group II	Group I	Group II	Group I	Group II
number	112	155	112	155	112	155
mean	73.45	71.93	78.20	76.30	72.45	70.98
std. dev.	11.03	12.75	13.98	13.72	13.90	13.93

Table 2

Project Scores

	Block II Project		Block III Project	
	Treatment Group	Comparison Group	Treatment Group	Comparison Group
number	112	155	155	112
mean	81.20	83.20	77.80	77.40
std. dev.	13.80	12.40	14.70	15.10

Table 3

Descriptive Statistics for Survey Items

Project II Survey Item	Treatment Group (n=112) (choice of project)		Comparison Group (n=155) (choice of team)		p-value
	M	SD	M	SD	
Study time	2.190	1.030	2.313	0.952	0.310
Enjoyed working on project	2.848	0.830	3.174	0.934	0.003
Interested in the math of project	3.063	0.933	3.232	0.972	0.150
Interested in the topic of project	2.330	0.981	2.900	1.100	0.000
Improved my appreciation of probability and statistics	2.821	0.903	2.897	0.941	0.510
Improved my knowledge of probability and statistics	2.321	0.674	2.587	0.945	0.008
Want to learn more about probability and statistics	3.179	0.942	3.342	0.943	0.160
Want to learn more about the topic	3.009	0.915	3.400	0.964	0.001
Project III Survey Item	Treatment Group (n=155) (choice of project)		Comparison Group (n=112) (choice of team)		p-value
Study time	2.780	1.080	2.470	1.070	0.023
Enjoyed working on project	2.852	0.851	3.071	0.946	0.052
Interested in math of project	3.150	1.010	3.150	1.080	0.980
Interested in topic of project	2.542	0.948	2.790	1.020	0.041
Improved my appreciation of probability and statistics	2.710	0.940	2.790	1.010	0.490
Improved my knowledge of probability and statistics	2.103	0.695	2.250	0.777	0.110
Want to learn more about probability and statistics	3.258	0.859	3.295	0.936	0.740
Want to learn more about the topic	3.168	0.918	3.241	0.923	0.520

Note. The scale used for all survey items (except study time) was:

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree

Table 4

Project Preferences

Block II Project	All Students	Females	Males	Major A	Major B	Major C
Bombs	55.4 %	38.1 %	59.3 %	56.0 %	73.7 %	50.0 %
Ball games	31.3 %	33.3 %	30.8 %	32.0 %	10.5 %	36.8 %
Babies	13.4%	25.6 %	09.9 %	12.0 %	15.8 %	13.2 %
Block II Project						
Food for Thought	44.5 %	65.5 %	39.7 %	62.1 %	40.0 %	40.6 %
Military Life	13.5 %	17.2 %	12.7 %	06.9 %	03.3 %	18.8 %
Collegiate Life	41.9 %	17.2 %	47.6 %	31.0 %	56.7 %	40.6 %

Table 5

General Preferences

Would you prefer to:	Number	Percent
Choose my project	54	32.3 %
Choose my team mates	150	56.2 %
Doesn't matter	63	23.6 %
Would you prefer to:		
Work alone	31	11.6 %
Work with a team	191	71.5 %
Doesn't matter	45	16.9 %
Would you prefer to:		
Do a project designed by the instructors	155	58.1 %
Design my own project	38	14.2 %
Doesn't matter	74	27.7 %

Appendix 1

Descriptions of Block II Projects

Below are descriptions of three Block II Projects. Choose the one project that interests you most.

[ ] Bombs. You are to verify the probabilities in an excerpt from Tom Clancy's "Debt of Honor." Given a number of bombs and the probability of a hit for each bomb, you will calculate the probability that at least one of the ten missile silos will survive.

[ ] Ball Games. You are an assistant to Coach DeBerry. Using historical home and away winning percentages, you will calculate the probability of winning the next three games and the probability of winning at least two of the next three games.

[ ] Babies. In response to a question posed by a reader in the "Ask Marilyn" column, you will calculate the probability that the family has exactly three boys. You will also calculate the probability that the family has three boys given one is a boy.

Appendix 2

Descriptions of Block III Projects

Below are descriptions of three Block III Projects. Choose the one project that interests you most.

[ ] Food for Thought. You will try to answer the following questions:

- What is the average cost of a meal at McDonald's?
- Do freshmen and seniors order different amounts of pizza?
- Do Academy personnel eat more take-out food than the Average American?

[ ] Military Life. You will try to answer the following questions:

- What is the average size of a military member's family?
- Do Air Force members move more often than their civilian counterparts?
- Are cadets high risk drivers as compared to officers?

[ ] College Life. You will try to answer the following questions:

- What is the average weekly study time of a cadet?
- Do Air Force Academy cadets carry a heavier credit hour load than civilian students?
- Are Air Force Academy grades as inflated as Duke's?